DISTRIBUTION OF BEEF CATTLE IN SCOTLAND: HOW IMPORTANT IS AGRICULTURAL POLICY?

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Distribution of Beef Cattle in Scotland: How Important is Agricultural Policy?

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Abstract

If one observe aggregated cattle figures for Scotland for more than a century it is possible to perceive that that cattle numbers seem to react strongly to agricultural policy (e.g., livestock subsidies before 1973, UK becoming part to the European Community). The purpose the paper is to provide a regional view of this result, namely whether the same trend can be observed if the analysis is done by Scottish regions. For this purpose, we assembled a panel dataset for 11 Scottish regions for the period 1959 until 2008. We specialised the analysis on beef cattle. We use simple regression techniques to verify whether there have been changes in the regional shares of beef cattle and whether beef cattle numbers in the different regions tend to converge to a steady state value. The results indicate that the data can be broken down into two major periods: before and after the accession to the European Community (EC). Furthermore, in most of the regions, accession implied changes in the regional shares (although shares are very stable over time). In terms of the convergence analysis, it is clear that accession to the EC affected the regional beef cattle steady state values.

Keywords: Agricultural policy, beef cattle economics, Scottish agriculture.

1. Introduction

Livestock is not only an important sector of Scotland's economy but also a key component of its agriculture and rural areas. Furthermore, a recent study by the SAC-Rural Policy Centre (2008) showed that the reduction in the number of livestock (both sheep and cattle) from the uplands may have a number of consequences in terms of the economic, environmental and social sustainability of those areas.

This paper focuses on beef cattle, due to its importance for Scottish agriculture, and studies the sector from a historical and spatial perspective with the purpose of identifying trends and structural changes, and the influence that agricultural policy may have on the sector. Thus, the main questions addressed are the extent that policy drives productive behaviour and whether this behaviour is common for all the Scottish regions. The latter question is an important element due to the marked regional differences in Scotland and the presence of regional policy.

As a motivation for the paper, Figure 1 presents the evolution of cattle numbers between 1866 and 2007 using both dairy and beef cattle.[2] The figure allows identifying three periods which

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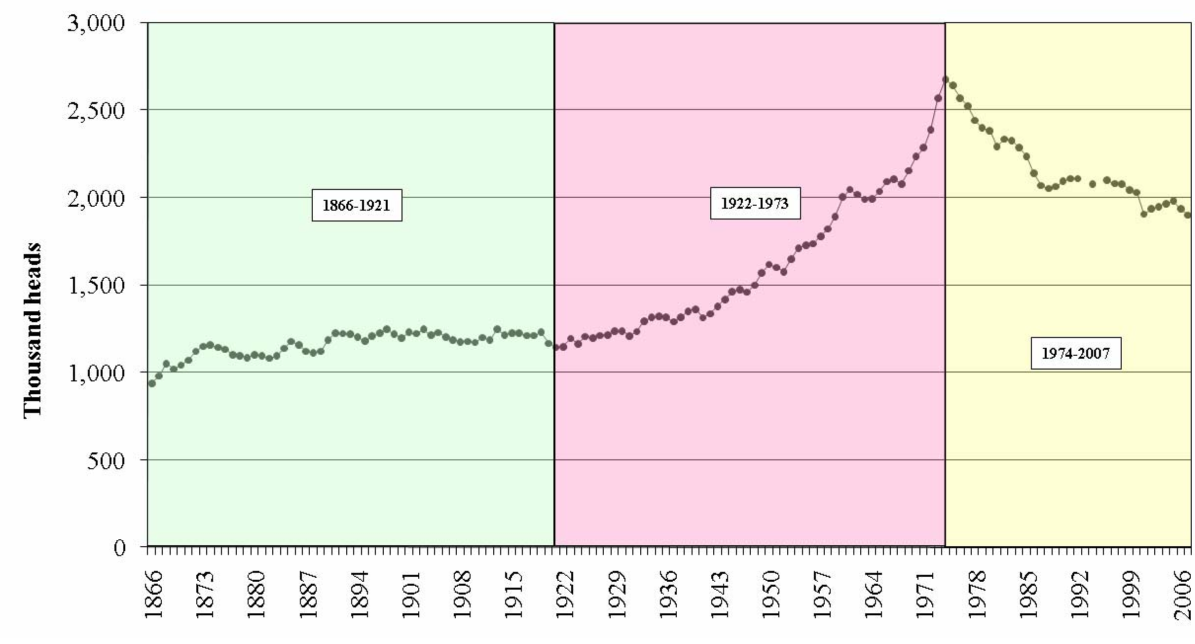
are highlighted in colour. The first period (highlighted in green), from 1866 until approximately 1922, shows a slightly growth in cattle numbers. This period can be identified with the stagnation period (i.e., the so-called the "Great Agricultural Depression") following the repeal of the Corn Laws (1846), the free trade policy that followed and the competition from imports (Robinson, 1988, pp. 31). However, the decrease in the total cattle numbers was offset by dairy cattle numbers as this was one of the few activities that showed profitability during the period (Robinson, 1988, pp. 37).

The second period in Figure 1 (in yellow) goes from approximately 1922 until 1973. Although, the 1920s could be consider erratic in terms of growth (the only two positive advantages was the relatively stability of prices and in terms of profitability the imports of cheap feedstuffs, Robinson, 1988, pp. 72), it certainly shows the number of animals growing at fast pace. This result can be attributed to a number of factors such as Government intervention expressed since the 1930s through a regime of subsidies (introduced in the case livestock in 1934[3]) and barriers to the import of meat or to the effect of research on the beef enterprise.

The third period, which could be broadly identified with the UK becoming part of the European Economic Community, shows a dramatic decrease in the number of animals, deeper at some points due to crisis such as the BSE and FMD crisis in 1996 and 2001, respectively.

Figure 1 - Scotland: Total cattle numbers (beef and dairy) 1866-2007



Source: Scottish Government.

Given the stylized facts shown in Figure 1 that on the aggregate cattle number seem to respond to agricultural policy, the question whether the same pattern can be appreciated when

[2] The reason for considering a figure that aggregates both dairy and beef cattle (both with different trends) is to provide a long term view of the influence of agricultural policy on agriculture. Disaggregated figures for both herds became available only since 1935; therefore it would not be possible to observe the effect of the depression period after the repeal of the Corn Laws in 1846.

[3] Cattle Industry (Emergency Provisions) Act, 1934.

we disaggregate the information on a regional basis; or in other terms, is the aggregated trend a good stylised fact of what happened at the level of Scottish regions?.

It is important to note that despite its importance for Scotland, the number of quantitative studies focusing on beef cattle and providing a regional analysis is limited and sparse (e.g., Carlyle, 1973; Bowler, 1981, partially Robinson, 1988; SAC, 2008). These studies show the existence of regional differences associated to particular characteristics (e.g., natural resources quality, size of markets).

The structure of the paper is the following: the next section deals with measuring the impact of policy on the distribution of cattle, which comprises a description of the assembled dataset, a brief analysis of the geographical changes of beef cattle in Scotland and the empirical methodology to use. This followed by the discussion of the obtained results. We finally present some conclusions.

2. Measuring the impact of policy on distribution of cattle

In this section we present the dataset used for the analysis, a description of the geographical changes observed in the data and the empirical methodology.

2.1 Data and definition of variables

In order to capture long term trends and identify clear structural changes, a dataset was assembled that considers information for the beef cattle sector (e.g., herd composition, farm size) in Scotland since 1959 broken down by regions.[4] The main interest in using historical data is because only by considering a historical overview it is possible to differentiate short term from long term trends and capture the response of farms to policy.

The main source of information was several issues of the Scottish compendia of agricultural statistics "Agricultural Statistics" and "Scottish Report on Scottish Agriculture". These publications provide detailed information from the June census of agriculture in Scotland.

A difficulty to be noted in assembling the dataset was not only changes in the reported regions and the various forms of geographical aggregations but also the differences in the way that the composition of the livestock herd was reported. For instance, until 1975 the entire cattle population was divided into dairy and beef cattle; however, since that year part of the herd is reported as dairy and beef cattle together (bulls for service and animals under one year old), due to their dual purposes. Due to this, the definition of the beef cattle population excluded both categories from the entire sample.[5]

In addition, to ensure homogeneity in the series, regions were classified according to the most aggregated classification in the sample, given a total of 11 regions (Shetland Island, Tayside,

[4] The assembling of a historical regional agricultural database for Scotland is an ongoing work that aims to provide statistical information for the analysis of resilience and sustainability of the agricultural sector in Scotland.

[5] The criterion used to construct this series was to get a homogeneous series of the beef cattle population. An alternative view could have been to consider all the animals stated as beef cattle before 1974 and the to consider that the change in the animal number from 1974 to 1975 was due to changes in the industry. However, as this is not probable we preferred the former alternative.

Central, Orkney Island, Fife, Strathclyde, Highland, Lothian, Dumfries and Galloway, North East Grampian and Borders)[6]. The collected information was assembled as a panel dataset in order to both control for regional heterogeneity and make for variables not available in the dataset. The total number of observations available in the dataset was 550 (11 regions times 50 years).

In addition to cattle numbers, policy variables were introduced to the dataset in the form of dichotomous variables (i.e., dummy variables). The periods considered for the dummies were 1959-73 (i.e., previous to the UK entry to the European Community), 1974-1992 (period previous to the McSharry reform), 1993-2004 (period post McSharry reform and before the introduction of the single farm payment) and 2005-2008 (period after the introduction of the single farm payment). Also, regional dummies were constructed (to use them as fixed effect terms) and dummies to account for the effect of the BSE outbreak (1996-1997) and the FMD outbreak (2001-2002).

2.2 Geographical changes in beef cattle in Scotland

Figure 1 presents plots of the 11 Scottish regions considered in the analysis plus also Scotland and some aggregated regions (i.e., North West, South East and South West).

Two patterns appear clearly in the data: the first pattern is that one that is common to the Scottish average and, second one, is that one that is common to most of the South West regions (excepting the Central region that follows the first pattern), Borders and Orkney Islands.

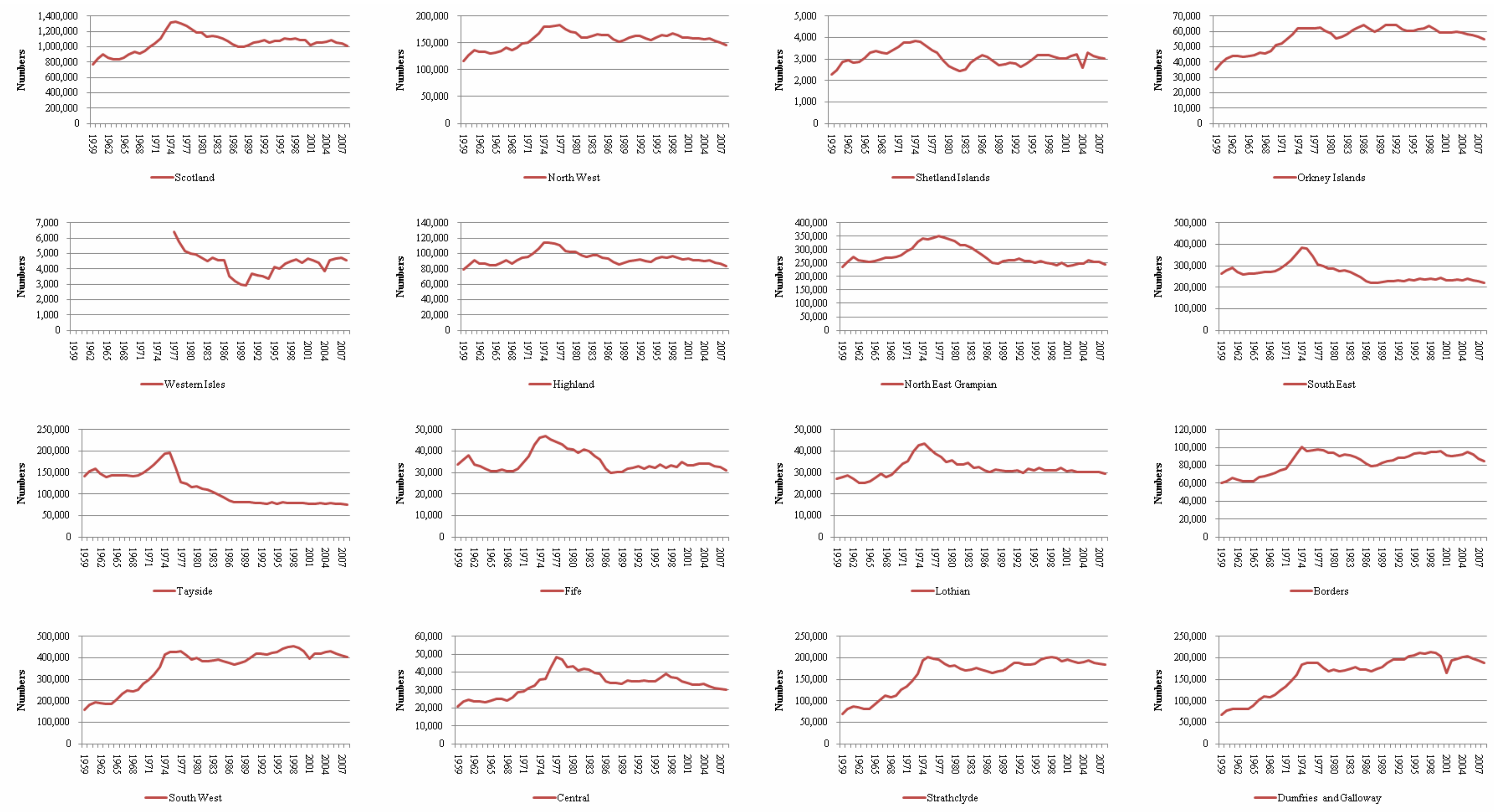
The first pattern can be broken into three periods: growth until before the entry to the European Community, contraction until approximately 1986 and stagnation since then.

The second pattern shows rapid growth until around 1975 and then a more modest growth. This indicates that excepting the case of Orkney, there has been an increase in the share of the cattle concentrated in the southern Scottish regions.

In both patterns the cattle stocks seems to converge to new values after the entry of the UK to the EC. This is something that we estimate later in the analysis of convergence.

[6] The Western Isles were excludes from the dataset due to the fact that their information started to be collected only in 1975.

Figure 1: Evolution of beef cattle in Scotland by region 1959-2008



2.3 Methodology

Two models were used to explore the effect that policy may have on the distribution of beef cattle in the Scottish regions. The first model taken from Herath et al. (2005) is given by the following panel data equation:

$$(1) \qquad Y_{it} = \sum_{k=1}^{K} \beta_k X_{k,it} + V_i + U_t + \varepsilon_{it}$$
$$i = 1,....,11; t = 1,....,50$$

Where Y_{it} is the share of beef cattle in region i in year t, $X_{k,it}$ represent k exogenous variables affecting the share of cattle in region i. β_k are the coefficients associate with the explanatory variables. V_i is the time-invariant, unobserved region-specific effect; U_t is the region-invariant, unobserved time-specific effect and ε_{it} is the random disturbance term.

The second model used consisted of adapting the economic convergence framework from Barro and Xala-i-Martin (1991, 1992), which allows estimation of long term trends and measures the degree of similarity in the way different regions evolve over time. In addition, this approach is flexible enough to allow policy changes to be introduced through intervention analysis (e.g., Harvey, 1993). Specifically, the model as presented in de la Fuente (1997) can be considered a linear approximation to the convergence equation from Barro and Xala-i-Martin. This is given by:

$$(2) \qquad y_{it+1} = x_i + (1-\beta) y_{it} + \varepsilon_{it}$$

Where $y_{it} = \ln\left(Q_{it} / Q_t \right)$ is the natural logarithm of the beef cattle stock in region i at time t normalised by the mean of the variable in the period. x_i summarises the determinants of the growth in beef cattle in region i and ε_{it} is the independent and identically distributed random disturbance term. Equation (2) can also be written in terms of first differences as in (3):

$$(3) \qquad \Delta y_{it} = x_i + \beta y_{it} + \varepsilon_{it}$$

Where $\Delta y_{it} = y_{it+1} - y_{it}$ is approximately equal to the growth rate of the beef cattle stock in region i, measured in deviation from the average growth of the sample. From (3) it is easy to note that the steady state value for y_{it} is given by (4):

$$(4) \qquad y^*{}_i = \frac{x_i}{\beta}$$

Taking expectations for both sides of (2), given initial conditions y_{i0} we get the no-stochastic equation in expected beef cattle stock $y^e{}_{it}$ as in (5):

$$(5) \qquad y^e{}_{it} = y^*{}_i + \left(y_{i0} - y^*{}_i \right)(1-\beta)^t$$

The fact that we are using a panel data allows us to estimate equation (2) using fixed effect terms to partially compensate for the lack of explanatory variables such beef cattle prices or costs of production. In addition, we introduce the effects of policy (measured by the dummy variables) as explanatory variables.

3. Estimation results and discussion

Tables 1 and 2 presented the results of the estimations of the models presented in the previous section. The first regression of Table 1 considers only fixed effects by region whilst the second one, considers the effect of the entry into the European Community to the shares.

Table 1: Regressions for the beef cattle shares

Variable	Dependent variable (y) = Share of beef cattle region i in total 1/					
	Coeff.	St. Dev.	t-stat	Coeff.	St. Dev.	t-stat
Fixed effects (x_i)						
d_shi	0.003	0.003	1.041	0.003	0.003	1.211
d_shi*d_74_08				-0.001	0.003	-0.181
d_ori	0.053	0.003	18.967	0.050	0.003	17.968
d_ori*d_74_08				0.005	0.003	1.654
d_hi	0.090	0.003	31.816	0.097	0.003	35.026
d_hi*d_74_08				-0.010	0.003	-3.142
d_gra	0.264	0.003	93.689	0.292	0.003	105.500
d_gra*d_74_08				-0.038	0.003	-12.106
d_tay	0.109	0.003	38.688	0.159	0.003	57.661
d_tay*d_74_08				-0.070	0.003	-22.067
d_fif	0.034	0.003	11.913	0.037	0.003	13.228
d_fif*d_74_08				-0.004	0.003	-1.314
d_lot	0.030	0.003	10.756	0.032	0.003	11.437
d_lot*d_74_08				-0.002	0.003	-0.573
d_bor	0.080	0.003	28.450	0.075	0.003	27.207
d_bor*d_74_08				0.007	0.003	2.170
d_cen	0.032	0.003	11.213	0.028	0.003	10.122
d_cen*d_74_08				0.005	0.003	1.584
d_str	0.152	0.003	53.851	0.115	0.003	41.480
d_str*d_74_08				0.051	0.003	16.238
d_dg	0.154	0.003	54.477	0.113	0.003	40.882
d_dg*d_74_08				0.056	0.003	17.736
	550 Observations			550 Observations		
	R^2 = 0.9309			R^2 = 0.9793		
	R^2 adj. = 0.9296			R^2 adj. = 0.9785		

Notes
1/ Excludes Western Isles

Legend

d_shi	Dummy Shetland island
d_ori	Dummy Orkney island
d_hi	Dummy Highland
d_gra	Dummy North East Grampian
d_tay	Dummy Tayside
d_fif	Dummy Fife
d_lot	Dummy Lothian
d_bor	Dummy Borders
d_cen	Dummy Central
d_str	Dummy Strathclyde

d_dg	Dummy Dumfries and Galloway
d_74_08	Dummy 1974-2008

It is important to note that other policy or event dummy variables (as the ones described in section 2.1) were tried into the regression without success. In addition, also a time effect (a constant for each period of time) was estimated in both models showing little variability.

In general, even when considering the entire period, the cattle shares were very stable as shown by the t statistics in the regression. In addition, the effect of the dummy representing the period after the UK entry into the European Community was very significant for several of the regions. The presence of positive and negative signs for those dummies indicates change in the regional shares.

The change in regional shares can be attributed to the presence of regional policy (e.g., Orkney) and also due to Government support toward areas with low diversity and where cattle is an important source of agricultural revenues such in Borders (Robinson, 1988).

Table 2 presents 4 regressions associated to the deviations of the regional stock of beef cattle with respect to the mean stock of beef cattle for Scotland (excluding Western Isles) that go from left to right in terms of the degree of disaggregation.

The first regression (first to the left) only considers fixed effect terms and the convergence coefficient is the same for all the regions. The second regression modifies the fixed effects by including a dummy variable for the period after the entry into the UK. Note that the convergence coefficient decreases from the first to the second regression from 0.94 to 0.88 indicating a slower convergence to the steady state situation.

The third regression is a variation from the first regression by considering that the coefficient of convergence is different for each region and the fifth regression is a similar modification to the second regression.

As shown in the table, most of the parameters of the regressions are very significant and so is the fit of all the regressions. The steady state values measured as the ratio of the number of cattle in the region with respect to the mean are presented in Table 3 for comparison. It should be noted that all the models predict similar results and the value for 2008 are very close to the steady state values. Given the change in trends after 1974, models 2 and 4 would be preferable to 1 and 3, and between 2 and 4 one would prefer 4 due to the fact that the convergence coefficient seem different by region, indicating that each one converge to their steady state values at different speed.

Table 2: Regressions of the deviations with respect to the mean

Variable	Dependent variable (y) = Log of the deviation of region i with respect to the country mean 1/											
	Coeff.	St. Dev.	t-stat	Coeff.	St. Dev.	t-stat	Coeff.	St. Dev.	t-stat	Coeff.	St. Dev.	t-stat
Fixed effects (x_i)												
d shi	-0.187	0.032	-5.795	-0.392	0.051	-7.690	-0.426	0.130	-3.283	-0.915	0.170	-5.370
d shi*d 74 08				-0.029	0.010	-2.805				-0.060	0.014	-4.260
d ori	-0.026	0.007	-3.650	-0.068	0.013	-5.344	-0.044	0.032	-1.391	-0.067	0.041	-1.616
d ori*d 74 08				0.010	0.010	0.977				0.010	0.012	0.825
d hi	-0.005	0.005	-1.020	-0.002	0.009	-0.262	-0.005	0.005	-1.074	-0.004	0.014	-0.275
d hi*d 74 08				-0.005	0.010	-0.494				-0.003	0.020	-0.133
d gra	0.053	0.011	4.816	0.131	0.020	6.606	0.036	0.055	0.658	0.028	0.086	0.323
d gra*d 74 08				-0.011	0.010	-1.082				0.002	0.015	0.121
d tay	-0.012	0.005	-2.274	0.052	0.012	4.238	-0.015	0.005	-2.870	0.041	0.016	2.519
d tay*d 74 08				-0.075	0.013	-5.600				-0.064	0.018	-3.630
d fif	-0.062	0.011	-5.855	-0.124	0.016	-7.568	-0.127	0.051	-2.470	-0.139	0.057	-2.458
d fif*d 74 08				-0.004	0.010	-0.364				-0.006	0.012	-0.459
d lot	-0.064	0.011	-5.601	-0.132	0.018	-7.193	-0.279	0.112	-2.495	-0.363	0.124	-2.937
d lot*d 74 08				-0.005	0.010	-0.490				-0.017	0.012	-1.421
d bor	-0.005	0.005	-1.070	-0.025	0.009	-2.680	-0.005	0.011	-0.412	-0.026	0.021	-1.227
d bor*d 74 08				0.015	0.010	1.478				0.015	0.013	1.178
d cen	-0.056	0.011	-5.036	-0.141	0.020	-7.059	-0.106	0.047	-2.246	-0.242	0.070	-3.444
d cen*d 74 08				0.021	0.010	2.061				0.035	0.014	2.552
d str	0.041	0.007	6.082	0.053	0.009	5.708	0.043	0.012	3.444	0.045	0.013	3.516
d str*d 74 08				0.026	0.012	2.284				0.011	0.020	0.568
d dg	0.042	0.007	6.284	0.053	0.009	5.755	0.043	0.011	3.819	0.044	0.011	3.962
d dg*d 74 08				0.029	0.012	2.464				0.009	0.018	0.484
(1-β)												
lag of y	0.946	0.009	101.870	0.880	0.015	57.937						
lag of y*d shi							0.876	0.038	23.285	0.721	0.052	13.999
lag of y*d ori							0.912	0.058	15.677	0.882	0.067	13.206
lag of y*d hi							0.919	0.079	11.676	0.901	0.154	5.857
lag of y*d gra							0.962	0.051	18.719	0.968	0.073	13.204
lag of y*d tay							0.973	0.014	67.592	0.899	0.025	36.234
lag of y*d fif							0.880	0.051	17.178	0.864	0.061	14.077
lag of y*d lot							0.750	0.101	7.391	0.662	0.116	5.681
lag of y*d bor							0.952	0.079	12.038	0.874	0.101	8.613
lag of y*d cen							0.898	0.044	20.251	0.794	0.059	13.420
lag of y*d str							0.942	0.023	40.436	0.919	0.046	20.125
lag of y*d dg							0.944	0.021	45.739	0.930	0.036	25.667
	539 Observations			539 Observations			539 Observations			539 Observations		
	R^2 = 0.9991			R^2 = 0.9992			R^2 = 0.9992			R^2 = 0.9992		
	R^2 adj. = 0.9991			R^2 adj. = 0.9992			R^2 adj. = 0.9991			R^2 adj. = 0.9992		

Notes
1/ Excludes Western Isles

Legend

d shi	Dummy Shetland island	d tay	Dummy Tayside	d cen	Dummy Central
d ori	Dummy Orkney island	d fif	Dummy Fife	d str	Dummy Strathclyde
d hi	Dummy Highland	d lot	Dummy Lothian	d dg	Dummy Dumfries and Galloway
d gra	Dummy North East Grampian	d bor	Dummy Borders	d 74 08	Dummy 1974-2008

Table 3: Comparison between latest year and steady state values

	2008	Steady state values			
		Model 1	Model 2	Model 3	Model 4
Shetland island	0.033	0.032	0.030	0.032	0.030
Orkney island	0.596	0.624	0.616	0.609	0.616
Highland	0.909	0.911	0.941	0.935	0.937
North East Grampian	2.680	2.658	2.717	2.563	2.538
Tayside	0.808	0.808	0.824	0.565	0.799
Fife	0.339	0.322	0.344	0.347	0.345
Lothian	0.322	0.311	0.320	0.328	0.325
Borders	0.926	0.904	0.920	0.908	0.919
Central	0.329	0.360	0.369	0.353	0.366
Strathclyde	2.002	2.120	1.945	2.086	2.020
Dumfries and Galloway	2.055	2.182	1.988	2.166	2.111

Note: Values are ratios with respect to the mean.

3. Conclusions

Aggregated cattle figures for Scotland for more than a century show that cattle numbers react strongly to agricultural policy (e.g., livestock subsidies before 1973, UK becoming part to the European Community).

The purpose the paper has been to provide a regional view of this result, namely whether the same trend can be observed if the analysis is done by Scottish regions. We used simple regression techniques to verify whether there have been changes in the regional shares of beef cattle and whether beef cattle numbers in the different regions tend to converge to a steady state value.

The results indicate that agricultural policy is an important driver of both trends and structural change and also a source of divergence amongst regions. Furthermore, the data can be broken down into two major periods: before and after the accession to the European Community (other sub-periods were also tried without success). Also in most of the regions, accession implied changes in the regional shares (although shares are very stable over time). In terms of the convergence analysis, it is clear that accession to the EC affected the steady state values for beef cattle expected for the regions.

Several further issues remain to investigate (as more data become available) such as whether the decline in cattle numbers is due to a combination of down-sizing or to farmers withdrawing from production.

4. References

Barro, R. and Sala-i-Martin, X. (1991) "Convergence Across State and Regions." Brookings Papers on Economic Activity, 1: 107-82.

Barro, R. and Sala-i-Martin, X. (1992) "Convergence” Journal of Political Economy, 100(2): 223-51.

Bowler, I. R. (1981). Regional specialisation in the agricultural industry. Journal of Agricultural Economics, 32: 45-55.

Bryden, J. and Houston, G. (1976). Agrarian Change in the Scottish Highlands. Martin Robertson in association with Highlands and Islands Development Board. London.

Carlyle, W. J. (1975). Livestock Markets in Scotland. Annals of the Association of American Geographers, 65 (3): 449-460.

De la Fuente, A. (1997). The empirics of growth and convergence: a selective review. Journal of Economic Dynamics and Control, 21: 23-73.

Harvey, A. C. (1993) Time Series Models, 2nd Edition. MIT Press: Massachusetts.

Herath, D., Weersink, A. and Line Carpentier, C. (2005). Spatial Dynamics of the Livestock Sector in the United States: Do Environmental Regulations Matter? Journal of Agricultural and Resource Economics, 30(1):45-48.

Robinson, G.M. (1988). Agricultural Change: Geographical Studies of British Agriculture. North British Publishing: Edinburgh.

SAC-Rural Policy Centre (2008). Farming’s Retreat from the Hills. SAC: Edinburgh.

Tracy, M. (1989). Government and Agriculture in Western Europe 1880-1988. Harvesters Wheatsheef, Exeter.